The ANSTO-CMDL Radon Program at MLO

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The ability to predict the impact of rapid development in the Asian Pacific region on climate is dependent upon an improved scientific understanding of the radiative forcing of aerosols and trace gases, as well as the efficient implementation of these processes in regional and global climate models. Finding suitable tools to evaluate the performance of transport, mixing, and chemical processes within such models is challenging.

The well-defined source and sink pathways of radon-222 make it an ideal tracer of atmospheric dynamics. Its origins are almost exclusively terrestrial, and because it is a noble gas that does not react chemically with other species, its predominant sink is by radioactive decay. The half-life of radon (3.81 days) is comparable with the lifetimes of short-lived atmospheric pollutants (e.g., NO_x, SO_2, CO, and O_3) and residence times of water and aerosols. This time scale is also comparable with many important aspects of atmospheric dynamics, making radon a useful tracer at local, regional, or global scales. This predictable behavior means measurements of radon concentration are sufficient to indicate whether an air mass has been in contact with land in the past several weeks. Consequently, the simulation of radon transport is currently one of the best evaluation tools for transport schemes in regional and global circulation models. Subgrid mixing processes also cause significant changes in radon concentrations. Thus comparisons between observed and modeled radon concentrations can be used to improve local mixing schemes. Changes in radon concentration can be measured with high precision and temporal resolution at permanent stations and on board ships with automated detectors.

The last decade witnessed the first serious attempts to model radon concentrations on global and regional scales and to compare the modeled results with observations. The purpose of radon simulations varied; some were aimed at the development or validation of subgrid mixing schemes and indication of regions associated with largest uncertainties [e.g., *Jacob and Prather,* 1990; *Stockwell et al.,* 1998], others at the intercomparison of models [e.g., *Genthon and Armengaud,* 1995] or the comparison of different meteorological input data sets [e.g., *Mahowald et al.,* 1997]. In general, a better understanding of the key atmospheric features that control transport, mixing, and distribution of radon has been sought by detailed comparisons of modeled radon time series and vertical profiles with the best radon data sets available [e.g., *Mahowald et al.,* 1997; *Stockwell et al.,* 1998; *Dentener et al.,* 1999]. *Dentener et al.* [1999] contrasted the modeled data for MLO with those from other surface baseline stations including Cape Grim, Tasmania, and Kerguelen, Crozet, and Amsterdam Islands, all in the Indian Ocean.

A first comprehensive evaluation and intercomparison of global atmospheric transport models using radon time series was published in 1997 [*Jacob et al.,* 1997]. The intercomparison, sponsored by the World Climate Research Program (WCRP), evaluated and compared convective and synoptic processes in 20 models. Results were compared with the observed mean radon concentrations.

Consequently, at MLO the focus remains on two uses for radon data: (1) as one of the selection criteria of baseline air samples, because it provides a quantitative, continuous measure of the influence of the Asian continent on air samples at MLO, and (2) as a tracer to test the accuracy of global-scale atmospheric transport models.

The present detection system was first launched in 1994 and has been improved in recent years. The fundamental characteristics of the instrumentation are included in *Summary Report No. 23* [*Hofmann et al.*, 1996]. A thorough discussion of the principle of operation of the radon detector can be found in *Whittlestone and Zahorowski* [1998]. It is pertinent to note that the lower limit of detection for the radon detector currently deployed at MLO (20 mBq m^{-3}) matches the lowest radon concentration reported for oceanic air.

The only instrument problem for this period (1989-present) is an apparent reduction in air sampling rate from late October 2000 until April 2001. Evidence from other equipment indicates that this was simply due to a faulty flow meter. The problem was subsequently rectified by installation of a new flow meter.

Most recently the MLO data recorded during the first Asian Pacific Regional Aerosol Characterization Experiment (ACE-Asia) Intensive Operation Period (IOP) (April–May 2001) were combined with corresponding time-series data from observations at two ACE-Asia surface stations: Kosan (Cheju Island, South Korea) and Hok Tsui (Hong Kong). The combined set is intended to be used in a model intercomparison exercise of two global chemical transport models in support of the IOP.

Data for the reported period may be obtained by contacting Wlodek Zahorowski (wlodek.zahorowski @ansto.gov.au).

REFERENCES

Dentener, F., J. Feichter, and A. Jeuken, Simulation of the transport of Rn^{222} using on-line and off-line global models at different horizontal resolutions: A detailed comparison with measurements, *Tellus, 51B*, 573-602, 1999.

Genthon, C., and A. Armengaud, Radon 222 as a comparative tracer of transport and mixing in two general circulation models of the atmosphere, *J. Geophys. Res., 100*, 2849-2866, 1995.

Hofmann, D.J., J.T. Peterson, and R.M. Rosson (Eds.), *Climate Monitoring and Diagnostics Laboratory No. 23 Summary Report 1994-1995*, 161 pp., NOAA Environ. Res. Labs., Boulder, CO, 1996.

Jacob, D., and M. Prather, Radon-222 as a test of convective transport in a general circulation model, *Tellus, 42B*, 118-134, 1990.

Jacob, D.J., et al., Evaluation of intercomparison of global atmospheric transport models using ^{222}Rn and other short-lived tracers, *J. Geophys. Res., 102*, 5953-5970, 1997.

Mahowald, N.M., P.J. Rasch, B.E. Eaton, S. Whittlestone, and R.G. Prinn, Transport of ^{222}radon to the remote troposphere using the Model of Atmospheric Transport and Chemistry and assimilated winds from ECMWF and the National Center for Environmental Prediction/NCAR, *J. Geophys. Res., 102*, 28,139-28,151, 1997.

Stockwell, D.Z., M.A. Kritz, M.P. Chippperfield, and J.A. Pyle, Validation of an off-line three-dimensional chemical transport model using observed radon profiles, 2, Model results, *J. Geophys. Res., 103*, 8433-8445, 1998.

Whittlestone, S., and W. Zahorowski, Baseline radon detectors for shipboard use: Development and deployment in the First Aerosol Characterization Experiment (ACE 1), *J. Geophys. Res., 103*, 16,743-16,751, 1998.